Personal Computer Build Manual/Tutorial 2011-2012

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What the scope of this tutorial is:

The scope of this tutorial is to guide anyone, with computer knowledge, interested in building their own personal computer. This guide covers all of the essential parts for successfully assembling a PC utilizing the latest build techniques. Furthermore, this tutorial will outline tools and materials needed for preparation and assembling of every vital PC component.

What the scope of this tutorial is not:

This tutorial is not intended for readers with zero computer knowledge. For example, this tutorial does not cover how to plug your keyboard in or attach a monitor. Additionally, this guide does not cover how to install an operating system, such as Microsoft Windows 7. The rationale behind the decision to omit this latter step is because an entire guide could be written about installing an operating system.

Where to Begin

Where everyone must begin before building a PC:

Before building a PC, planning for and purchasing of components needs to be done. Builders must ask themselves, "What do I need this PC for?" The answer to that question will inevitably set the budget for the build and make component selection easier. For example, some components may be omitted entirely if the PC is only being used for email or web-browsing. For this tutorial, a gaming PC will be built to showcase all vital components a PC of this caliber would have. Please see the Appendix for suggestions on where to purchase components for a PC.

The Essential Components

The following components essential for this build (See Fig. 1a):

- Computer Case
- Motherboard/Mainboard
- CPU
- Heat-sink/Fan
- Memory (SDRAM)
- Power Supply
- Video Card
- Hard Drive
- Media (DVD/Blu-Ray) Player/Writer
- Serial Advanced Technology Attachment Cables (SATA)
- Thermal Compound for CPU
- Assorted Fasteners
- Tools (types vary depending on the parts)

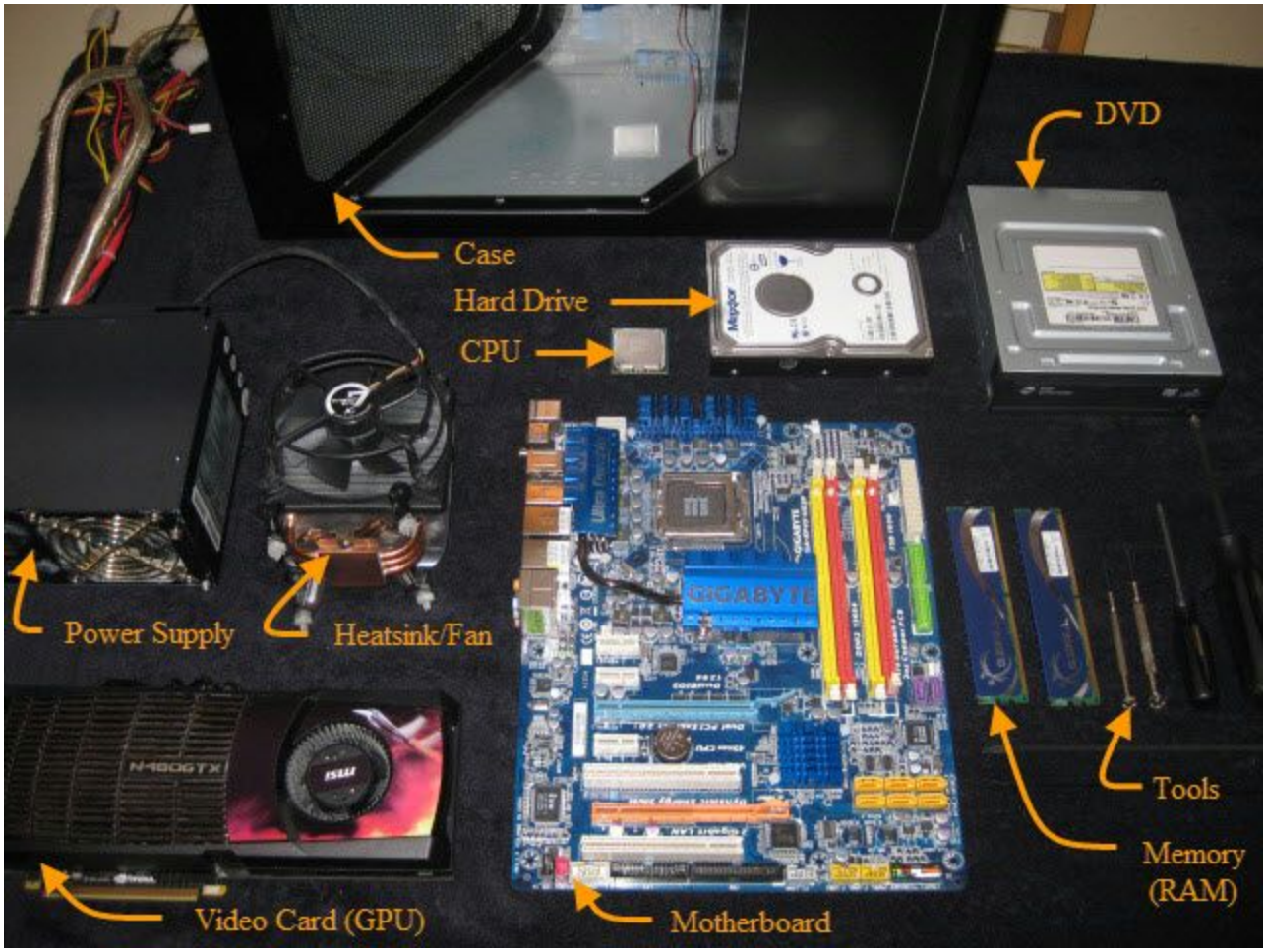

Fig. 1a: The Essential Components for Building a PC

The computer case and considerations

The computer case is an important purchase because it acts as a house for every component. You want a case with plenty of room and good airflow. The case should have several fans which pull in air from the front and exhaust air out the back or top. This is to ensure air is forced over every component for proper cooling. Additionally, the case should have many rooms, or drive bays, so several components may be added. Finally, the case should be user friendly; for example, it should not require screws or fasteners to secure components or have sharp, metal edges inside.

The motherboard and considerations

The motherboard or mainboard is like a person inside a house, or case, which brings all of the main components together and allows them to communicate. Motherboards are typically categorized by their processor socket. In addition, motherboards are classified by their chipset, which are typically variants from AMD or Intel. This is important because depending on the choice a corresponding CPU must be selected to fit in the motherboard socket and communicate with the chipset (See Fig. 1b).

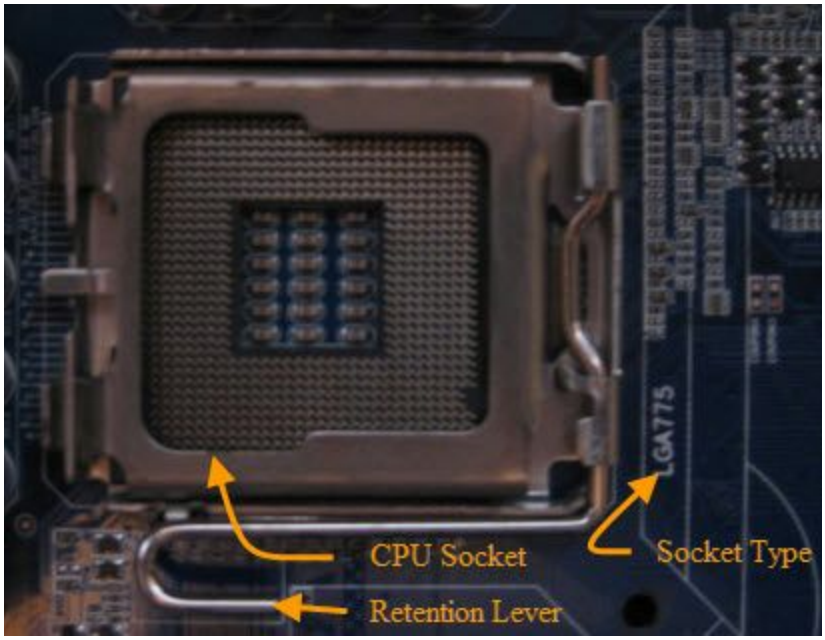

Fig. 1b: The Motherboard CPU Socket (Intel LGA775 Shown)

A motherboard should have several DDR2 / DDR3 memory slots (More on memory later), support PCI Express video, built in LAN and Audio chips, and have several SATA interfaces for connecting peripherals, such as hard drives and media (DVD) players. Typical brands of motherboards worth mentioning are manufactured by Asus, Intel, Gigabyte and MSI. For this guide, motherboards from Gigabyte and MSI were used. A motherboard manual should be read carefully before any build to ensure compatible components are purchased. Most motherboard manuals can be downloaded for free from the manufacturer's website.

The Central Processing Unit (CPU) and considerations

The CPU is the brain of every PC that calculates binary numbers at a high rate. Typical variants found in PCs are manufactured by AMD and Intel. Whatever the brand, the CPU must be compatible with the motherboard socket and chipset. Most modern processors contain multiple cores, which allow the computer to multitask several programs at once. For this build, an Intel Core2 Duo and Core i5 were used and have two cores and four cores, respectively.

The heat-sink / fan and considerations

Every CPU must have some way to dissipate heat; therefore, most CPUs come with a heat-sink/fan combo in the box. Depending on the build, the included heat-sink/fan may not be adequate enough to cool and it may be beneficial to buy a combo separately. If they are purchased separately, care must be taken to ensure the heat-sink and fan are compatible with the CPU. The heat-sink usually comes with a fan attached, but not always. It is recommended that a fan is included at the time of purchase. Some heat-sinks include multiple fans, which pull air through the cooling fins of the heat-sink and push air out the back of the computer case. Heat-sinks are attached to the motherboard by screws or push-pins and tightly rest against the CPU face. For this build, a standard heat-sink and fan were used.

Memory (SDRAM) and considerations

Memory acts as temporary storage for data from programs and software. The memory distributes this information to the CPU or other components very quickly. Memory modules are usually purchased in pairs of two or three, but sometimes just one module will suffice. Modern memory modules are sold in gigabytes and are classified as double data rate, synchronous dynamic random-access memory (SDRAM) . There are many different brands of memory, but the main focus when purchasing memory is to choose according to the motherboard specifications. For this build, DDR2[1] & DDR3[2] SDRAM manufactured by G.SKILL was used in pairs of two modules, two gigabytes each, for a total of four gigabytes.

The Power Supply and Considerations

The power supply is important because it distributes energy to all of the components. Choosing a power supply adequate to do this is crucial because today's components can be very demanding. Having an underrated power supply could jeopardize the entire build and make it unstable. For a general PC build, a 600 watt power supply should be sufficient. PCs with dedicated graphics cards for gaming may need more power, such as a 750 watt or 1000 watt power supply would deliver. There are many online calculators for taking the guesswork out of choosing the right power supply, such as the one provided by Newegg.com. This build features a 750 watt power supply from Corsair.

The Video Card and Considerations

A modern video card processes graphical information from programs, web-based video streams, and media players, such as DVD and Blu-Ray. The benefits of having a dedicated video card is to efficiently free up calculations a CPU would otherwise have to do, making the PC faster. However, depending on the purpose of the build, a video card may not be needed. This is because newer processors have built-in integrated graphics on the CPU, such as the Core i7 series from Intel. Since this build is for gaming, a video card from Nvidia was used. When selecting a video card, especially for gaming, a good rule of thumb is to check and see what the desired game recommends. All games come out with minimum and recommended specifications for experiencing smooth gameplay. An example of such specifications can be found here, which highlights Bethesda's Skyrim. Additionally, a video card must be compatible with the motherboard and it's interface, such as, PCI Express.

The Hard Drive and Considerations

Today's hard drives (HDD) come in gigabit and terabit capacities. Additionally, there are new solid state drives (SSD), that use flash based memory to store data. These newer drives are extremely fast and efficient, but lack the capacity of traditional hard disks. However, SSDs are quite expensive at the time of this build, so a standard 500 gigabyte HDD from Intel was used. Most modern hard drives use the serial advanced technology attachment (SATA) for connecting to the motherboard.

Media (DVD/Blu-Ray) Player/Writer and Considerations

Some type of media player, whether DVD or Blu-Ray needs to be present. This will allow installation of an operating system, such as Microsoft Windows 7. Most software requires a media player for

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[1] Double data rate, synchronous memory which replaces the original DDR specification (DDR3 SDRAM (n.d.) In Wikipedia online. Retrieved from http://en.wikipedia.org/wiki/DDR2_SDRAM)

[2] Double data rate, synchronous memory which is twice as fast as the DDR2 specification (DDR3 SDRAM (n.d.) In Wikipedia online. Retrieved from http://en.wikipedia.org/wiki/DDR3_SDRAM)

installation. Additionally, a media player will allow for movie playback and burning files to disk. For this build, a standard DVD/write player was used.

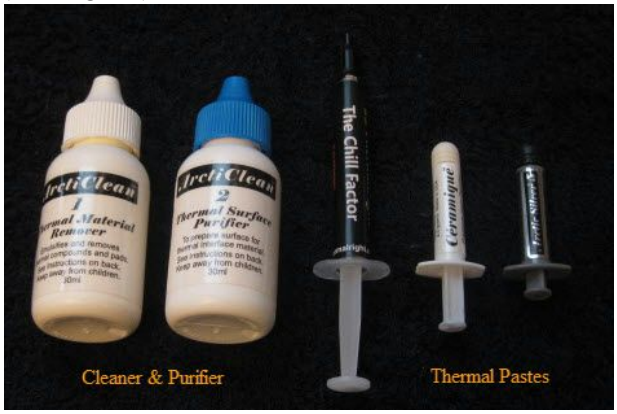
The Serial Cables (SATA)

Serial advanced technology attachment cables (SATA)[3] allow devices, such as, hard disks and media players to be attached to the motherboard to communicate. Most motherboards include SATA cables and other various cables in the box (See Fig. 1c).

Fig. 1c: Assortment of Cables Included with Motherboard (SATA cables are yellow)

Thermal Compound Considerations

There are many imperfections in the metal of the heat-sink face, which causes inefficient heat transfer from the CPU. Therefore, a thermal compound is applied between the CPU and Heat-sink to fill in these gaps and enhance heat transfer. There are several forms of compounds to choose from and include materials such as, ceramic or silver. This build uses a kit purchased from Arctic Silver Inc. which includes cleaning and purifying solutions to prepare the surfaces for the application of thermal compound (See Fig. 1d).



[3] Newer, high-speed interface that replaces parallel ATA or IDE for connecting hard disks and optical drives. (Serial ATA (n.d.) In Wikipedia online. Retrieved from http://en.wikipedia.org/wiki/SATA)

Fig. 1d: An Assortment of Cleaning Solutions and Thermal Compounds

Assorted fasteners secure components

Most cases come with an assortment of screws, motherboard stand-offs and fasteners to secure components in place. Sometimes these fasteners are included with the motherboard as well. It's a good idea to keep these fasteners in a plastic bag or small box for future builds (See Fig. 1c).

Fig. 1c: An Assortment of Fasteners for Securing Components

Tools needed to build PC

For this build, an assortment of small, Phillips-head screw drivers and a crescent wrench was used for the various attachments. Specialized tool kits are available for PC building, but are not required.

The Build Tutorial

Step by step instructions on how to put it all together

Step 1: Read motherboard manual thoroughly

This step is crucial to ensure a successful build and familiarize one's self with every feature of the motherboard. Have the motherboard manual on hand throughout the entire build process. Many steps will refer back to reading the motherboard manual.

Step 2: Prepare CPU for installation

The CPU needs prepared before installing onto the motherboard and attaching a heat-sink to it. Use a specialized cleaner or rubbing alcohol to purify the surface of the CPU. This can be accomplished by applying a small drop and a cotton swab (See Fig. 2a). After the surface is clean, a thermal compound needs to be applied. Squeeze a small, rice-sized drop of thermal paste in the middle of the CPU core (See Fig. 2b). The thermal paste should be spread evenly over the surface of the CPU face. There are many techniques for doing this, but using a sandwich bag over an index finger is efficient (See Fig. 2c). Once done, the CPU face should have a very thin, even layer of compound on its surface (See Fig. 2d).

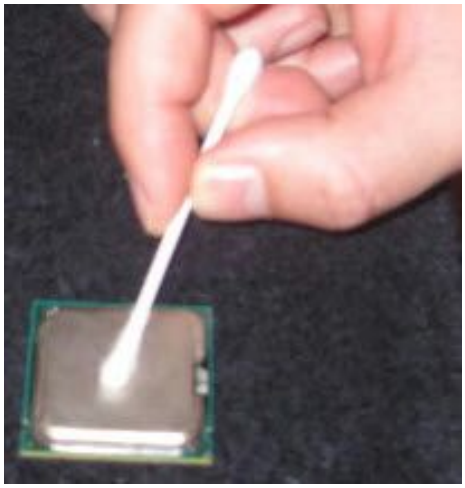


Fig. 2a: Purifying CPU Surface with Cotton Swab

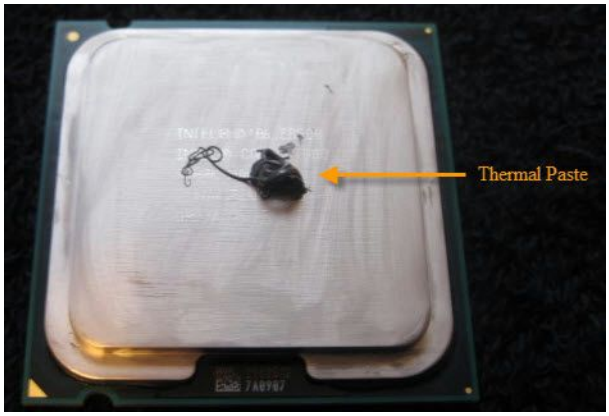


Fig. 2b: Applying Thermal Compound

Fig. 2c: Spreading Compound with Plastic Bag over Finger

Fig. 2d: Thermal Compound Spread Evenly over Surface of CPU

Step 3: Attach CPU to motherboard socket

The motherboard socket consists of a retainer spring and hinged bracket. Open this bracket up and rest the CPU carefully down on the socket (See Fig. 3a). The CPU is designed to fit in one way by utilizing keyed slots, which interface with teeth on the socket. Please ensure these are lined up before closing the bracket and securing the retainer spring (See Fig. 3b).

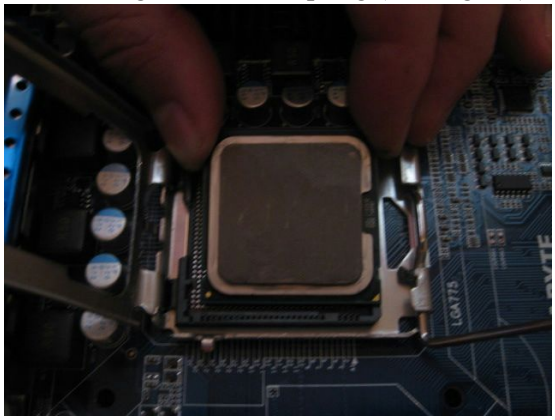


Fig. 3a: Installing CPU to Motherboard Socket

Fig. 3b: CPU Secured in Motherboard Socket

Step 4: Attach heat-sink/fan to motherboard and CPU

Clean and prepare the heat-sink face the same as in Step 2. Do not apply thermal compound. Once cleaned, carefully rest the heat-sink down to the CPU face. Line up the heat-sink's four screws or push-pins with the corresponding motherboard holes (See Fig 4a). Once lined up, secure the heat-sink firmly to the motherboard with the four screws or pushpins. Refer to the heat-sink manual for this step.

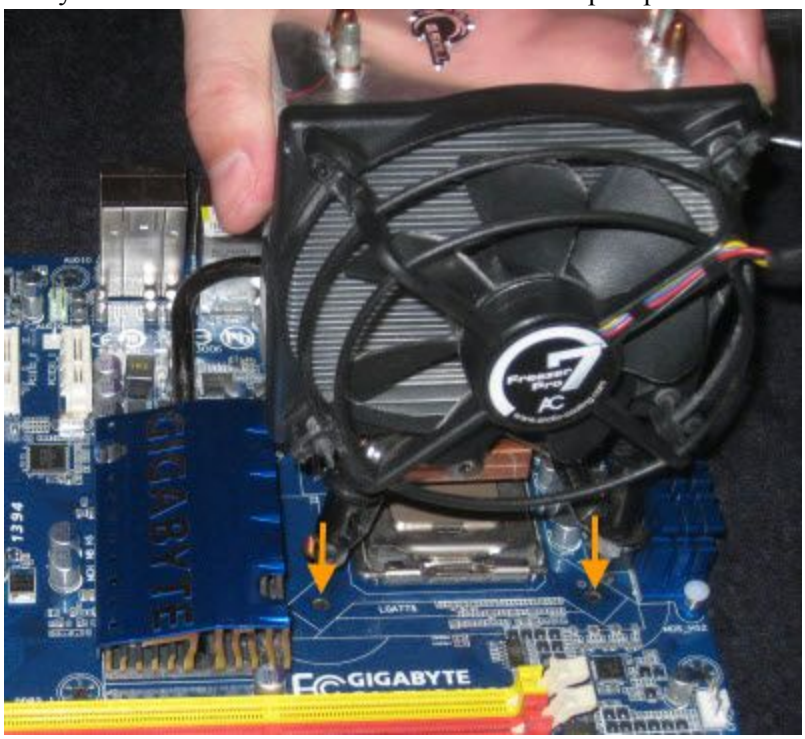


Fig. 4a: Lining up Heat-Sink/Fan

Step 5: Attach motherboard to case

From the assortment of fasteners, locate several stand-off screws that correspond with the number of mounting holes on the motherboard (See Fig. 5a). Mark which holes will need stand-off screws using a marker or pen on the case mounting plate, where the motherboard will rest. Insert a stand-off screw where every mark is ensuring they are fully engaged with the mounting plate. This can be done with a small crescent wrench. Once all stand-off screws are in place, rest the motherboard down on the stand-offs and use Phillips-head screws included with the motherboard to secure it.

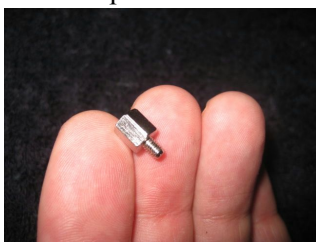


Fig. 5a: Motherboard Stand-Off Screw

Step 6: Install memory (SDRAM) to motherboard

Insert the memory module(s) into the corresponding slots on the motherboard. Refer to the motherboard manual to see which color combination should be used for memory pairs. For the motherboard in this

tutorial, it is required that one pair of modules reside in the yellow memory slots. Additional pairs would be placed in the red memory slots. Press firmly down on the memory module until the retention levers make a audible “click” and fully secures the memory in place (See Fig. 6a).

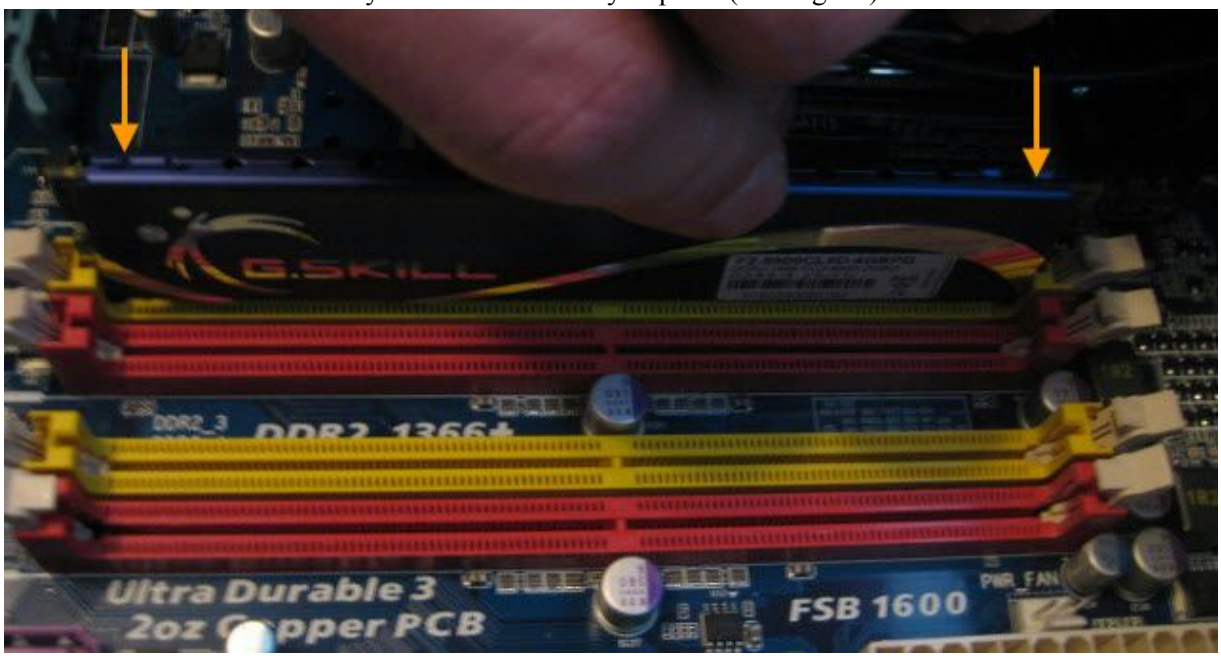


Fig. 6a: Installing Memory

Step 7: Install power supply

Some power supplies come pre-installed with the purchased case. If not, it’s usually a good idea to install this now. Some power supplies mount above the motherboard and some below. For this build, the power supply is mounted below the motherboard (See Fig. 7a). Power supplies typically mount with four Phillips-head screws. Once installed, start routing cables where needed for various components, but avoid using zip-ties until everything is hooked up.

⚠ Never plug in the power supply until the build is complete.

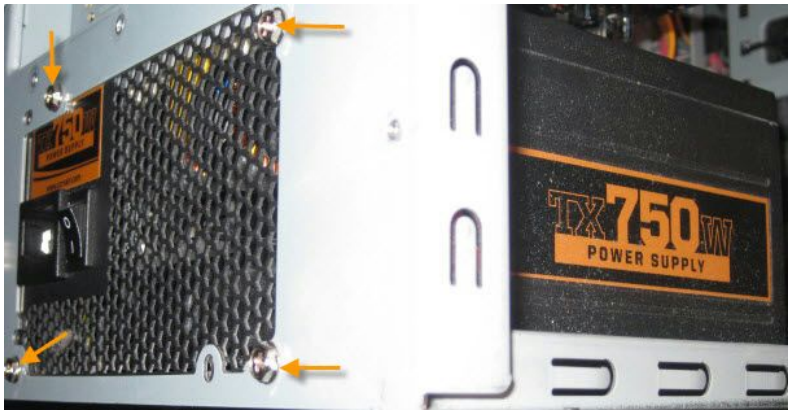


Fig. 7a: Power Supply Installed

Step 8: Install video card

Seat the video card down into the corresponding PCI Express slot (See Fig. 8a). A plastic retention clip on the slot will make an audible “click” when the card is fully seated. Once in place, secure the video card

with screws or, depending on the case, retention clips. Refer to the video card manual when performing this step. Some video cards, such as this, require an external power source. Attach the required power cables from the power supply to the video card (See Fig. 8b).

Fig. 8a: Installing Video Card

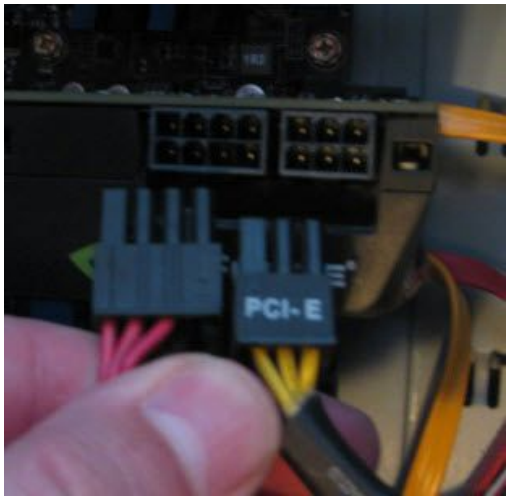


Fig. 8b: Attach Power Cables to Video Card

Step 9: Install DVD / Hard Drive

This step will cover installing two components, since the process is essentially the same. Find an open drive bay in the case and insert the media player or hard drive inside (See Fig. 9a). Most modern cases have retention clips that lock these devices in place. If not, use four screws usually included with the drive. Refer to the case manual for this step. After the devices are secure in the case, attach a power cable from the power supply to each device. Also, attach a colored SATA cable to each device (See Fig. 9b).

Fig. 9a: Installing Media (DVD) device

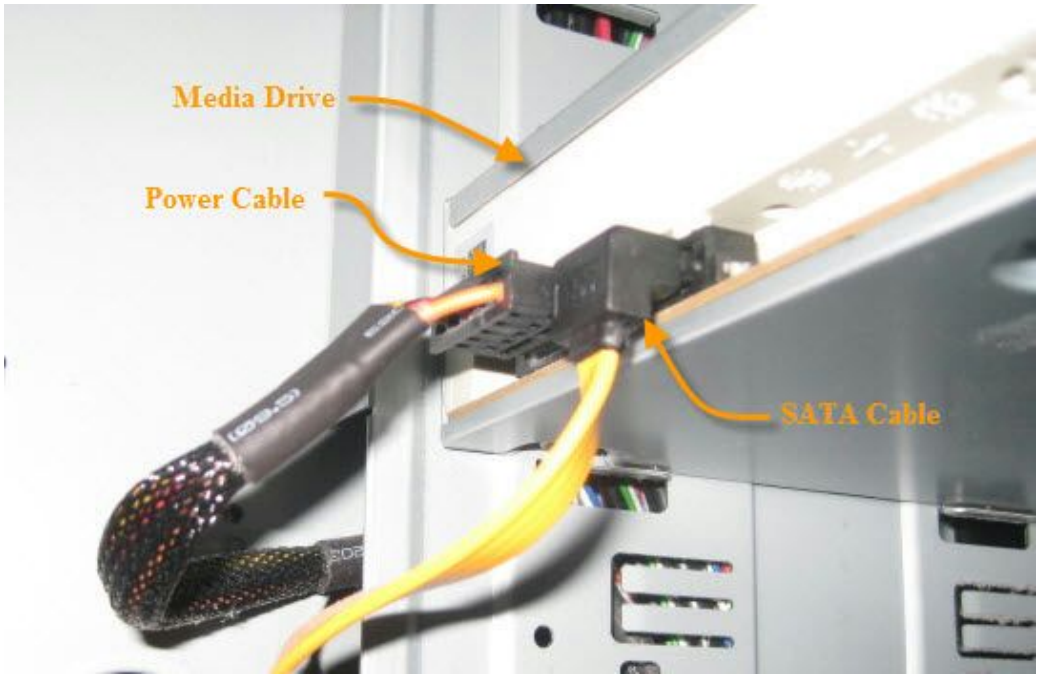


Fig. 9b: Power Cable / SATA Cable Attached

Step 10: Making the connections

So far, some of the cable connections have already been made to various components. Now, it's time to ensure these components are hooked to the motherboard and power supply. **It is very important the motherboard manual is followed during this step**. These are the items that must be checked when making connections:

- Connect all SATA cables from devices to motherboard SATA array (See Fig. 10a)
- Connect all main power cables to the motherboard. There are usually two cables required for this. (See Fig. 10b)
- Connect the heat-sink fan cable to the motherboard
  (⚠ **Important:** Follow directions in motherboard manual)
- Connect the case fans with cables from the power supply
- Connect the power on/off, reset, HD light activity cables from the case to the motherboard
  (⚠ **Important:** Follow directions in motherboard manual)

Fig. 10a: Typical SATA Array on Motherboard

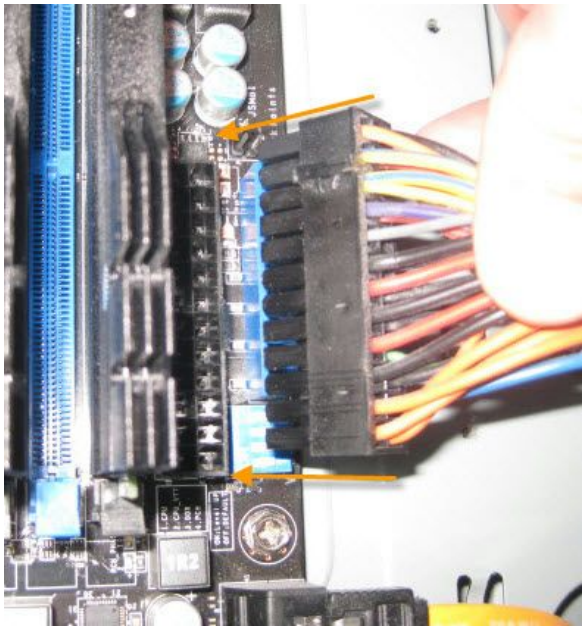


Fig. 10b: Connecting Main Power Cable

Step 11: Powering on the PC

Attach a monitor to the video card and power on the monitor. You will need to see if the motherboard splash screen appears after powering on the system. Once all the connections are made, double check to see if any were missed. Pay particular attention to the heat-sink fan connection as the CPU will overheat very fast if not connected. After checking every connection, attach a power cord to the power supply and activate the switch on the back. The power supply will be live and the system is ready to be turned on. Keep in mind, the case door should not be attached during this step. Power on the PC using the ON button located on the case **while looking directly at the heat-sink fan only**. Make sure the heat-sink fan is spinning. **If it is not spinning, power down the system immediately.** Once sure that the heat-sink fan is

working, check every case fan and make sure they are spinning. Look at the monitor and see if the motherboard splash screen is up. If the system fails to power up, check the connections again, especially the ON/OFF connection from the case to the motherboard (See motherboard manual).

Step 12: Finalizing the build

The build is essentially complete once Step 11 is satisfied. Here are the next items that should be done to finalize the build:

- Tidy up loose cables with zip-ties or wire organizers
- Attach a keyboard and mouse
- Attach an Ethernet cable (If not using wireless)
- Attach the case door
- Install the operating system to the hard drive
- Install updated motherboard drivers from manufacturer website
- Install device drivers and software updates from manufacturer website
- Update operating system online
- Install additional programs and software

Troubleshooting when things go unexpected

Inevitably, something does not go as planned during or after a PC build. Do not fret; the problem is usually simple to remedy. Use this list of helpful troubleshooting techniques for advice:

Problem	**Solution**
The CPU will not properly sit in the motherboard socket. -CPU will not allow retention latch to close over the CPU.	This is usually because the CPU is incorrectly oriented in the motherboard socket. Be sure the keyed slots in the CPU line up with the keys or "teeth" on the socket.
Heat-sink does not interface tight enough to the CPU face/does not secure tightly to the motherboard.	Ensure the correct heat-sink was purchased to correspond with the CPU used. If the heat-sink uses push-pins as a fastener, please make sure they are fully engaged on the back of the motherboard.
Memory (SDRAM) does not engage the side retention levers after installing.	With an index finger and thumb, push the memory in evenly on both sides until the retention levers engage. Sometimes, this is not enough, and the retention levers can be manually engaged around the SDRAM with minimal force using a finger.
The build is complete, but the **PC does not power on.**	Be sure the main power cable is connected to the power supply. Make sure the power supply button is set to "ON." Additionally, make sure the case connection wires leading to the "ON" button are properly located to the terminals on the motherboard (See motherboard manual). Finally, ensure the main power connections from the

	power supply are connected to the motherboard.
Heat-sink fan does not power on with system. -Case fan does not power on with system.	Immediately shut the system off. Ensure the fan power cord is seated with the motherboard terminal. Additionally, the fan may be powered directly by the power supply. If the fan still fails to power on, try a different fan.
System powers on but **motherboard / BIOS[4] splash screen does not appear**.	This is usually due to SDRAM not seated fully. Please ensure the modules are fully seated. Also, one module may be used instead of a pair to test various slots/modules (Refer to motherboard manual for SDRAM placement). Make sure the video card is properly seated. Ensure a monitor is connected and turned on.

[4] Basic Input Output System (BIOS (n.d.) In Wikipedia online. Retrieved from http://en.wikipedia.org/wiki/BIOS)